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(54) PROCEDE DE FILTRAGE ADAPTATIF DE SIGNAUX, FILTRE ADAPTATIF DE SIGNAUX ET SUPPORT LISIBLE PAR UN ORDINATEUR ET DESTINE A CONSERVER UN PROGRAMME CONCU A CET EFFET

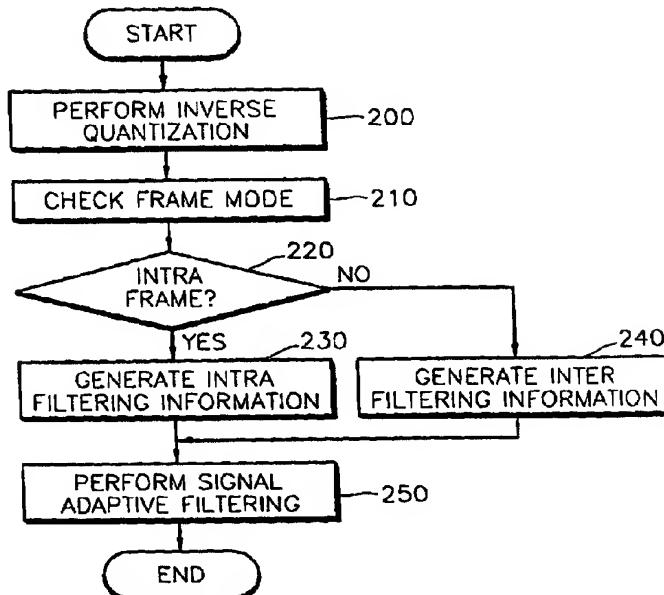
(54) SIGNAL ADAPTIVE FILTERING METHOD, SIGNAL ADAPTIVE FILTER AND COMPUTER READABLE MEDIUM FOR STORING PROGRAM THEREFOR

(57)

A signal adaptive filtering method for reducing blocking effect and ringing noise, a signal adaptive filter, and a computer readable medium. The signal adaptive filtering method capable of reducing blocking effect and ringing noise of image data when a frame is composed of blocks of a predetermined size includes the steps of: (a) generating blocking information for reducing the blocking effect and ringing information for reducing the ringing noise, from coefficients of predetermined pixels of the upper and left boundary regions of the data block when a frame obtained by deconstructing a bitstream image data for inverse quantization is an intraframe; and (b) adaptively filtering the image data passed through inverse quantization and inverse discrete cosine transform according to the generated blocking information and ringing information. Therefore, the blocking effect and ringing noise can be eliminated from the image restored from the block-based image, thereby enhancing the image restored from compression.

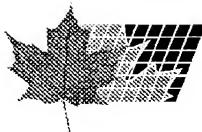
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(30) 1997/07/16 (1997/33253) KR

(54) **PROCEDE DE FILTRAGE ADAPTATIF DE SIGNAUX, FILTRE  
ADAPTATIF DE SIGNAUX ET SUPPORT LISIBLE PAR UN  
ORDINATEUR ET DESTINE A CONSERVER UN  
PROGRAMME CONCU A CET EFFET**  
(54) **SIGNAL ADAPTIVE FILTERING METHOD, SIGNAL  
ADAPTIVE FILTER AND COMPUTER READABLE MEDIUM  
FOR STORING PROGRAM THEREFOR**



(57) L'invention concerne un procédé de filtrage adaptatif de signaux servant à diminuer l'effet de blocage et le bruit de suroscillation, un filtre adaptatif de signaux ainsi qu'un support lisible par un ordinateur. Ce procédé de filtrage destiné à diminuer l'effet de blocage et le bruit de suroscillation des données d'image, lorsqu'une trame

(57) A signal adaptive filtering method for reducing blocking effect and ringing noise, a signal adaptive filter, and a computer readable medium. The signal adaptive filtering method capable of reducing blocking effect and ringing noise of image data when a frame is composed of blocks of a predetermined size includes the steps of: (a)



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est composée de blocs de dimensions déterminées, comprend les étapes consistant: (a) à produire des informations de blocage afin de réduire l'effet de blocage, et des informations de suroscillation afin de diminuer le bruit de suroscillation, à partir de coefficients de pixels déterminés des régions limitrophes supérieure et gauche du bloc de données, lorsque l'on obtient une trame par déconstruction des données d'image d'un train binaire, aux fins de quantification inverse dans une trame, et (b) à filtrer de manière adaptative les données d'image passées à travers cette quantification inverse et à travers une transformation en cosinus discrets inverse, en fonction des informations produites de blocage et de suroscillation. Ainsi, on peut éliminer l'effet de blocage et le bruit de suroscillation d'une image restaurée à partir de l'image à base de blocs, ce qui permet de rehausser l'image restaurée à partir de la compression.

generating blocking information for reducing the blocking effect and ringing information for reducing the ringing noise, from coefficients of predetermined pixels of the upper and left boundary regions of the data block when a frame obtained by deconstructing a bitstream image data for inverse quantization is an intraframe; and (b) adaptively filtering the image data passed through inverse quantization and inverse discrete cosine transform according to the generated blocking information and ringing information. Therefore, the blocking effect and ringing noise can be eliminated from the image restored from the block-based image, thereby enhancing the image restored from compression.



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<p>(21) International Application Number: PCT/KR98/00169</p> <p>(22) International Filing Date: 18 June 1998 (18.06.98)</p> <p>(30) Priority Data: 1997/33253 16 July 1997 (16.07.97) KR</p> <p>(71) Applicant (for all designated States except US): SAMSUNG ELECTRONICS CO., LTD. [KR/KR]; 416, Maetan-dong, Paldal-gu, Suwon-city, Kyungki-do 442-373 (KR).</p> <p>(72) Inventors; and</p> <p>(75) Inventors/Applicants (for US only): LEE, Yung, Lyul [KR/KR]; 2-506, Keukdong Apt., 192, Karak-dong, Songpa-gu, Seoul 138-160 (KR). PARK, Hyun, Wook [KR/KR]; D-2, Kwahakwon Apt., 109, Heogi-dong, Dongdaemun-gu, Seoul 130-050 (KR).</p> <p>(74) Agent: LEE, Young, Pil; The Cheonghwa Building, 1571-18, Seocho-dong, Seocho-gu, Seoul 137-073 (KR).</p>		
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<p>(54) Title: SIGNAL ADAPTIVE FILTERING METHOD, SIGNAL ADAPTIVE FILTER AND COMPUTER READABLE MEDIUM FOR STORING PROGRAM THEREFOR</p> <p>(57) Abstract</p> <p>A signal adaptive filtering method for reducing blocking effect and ringing noise, a signal adaptive filter, and a computer readable medium. The signal adaptive filtering method capable of reducing blocking effect and ringing noise of image data when a frame is composed of blocks of a predetermined size includes the steps of: (a) generating blocking information for reducing the blocking effect and ringing information for reducing the ringing noise, from coefficients of predetermined pixels of the upper and left boundary regions of the data block when a frame obtained by deconstructing a bit-stream image data for inverse quantization is an intraframe; and (b) adaptively filtering the image data passed through inverse quantization and inverse discrete cosine transform according to the generated blocking information and ringing information. Therefore, the blocking effect and ringing noise can be eliminated from the image restored from the block-based image, thereby enhancing the image restored from compression.</p>		
<pre> graph TD     START([START]) --&gt; 200[PERFORM INVERSE QUANTIZATION]     200 --&gt; 210[CHECK FRAME MODE]     210 -- NO --&gt; 240[GENERATE INTER FILTERING INFORMATION]     240 --&gt; 250[PERFORM SIGNAL ADAPTIVE FILTERING]     250 --&gt; END([END])     210 -- YES --&gt; 230[GENERATE INTRA FILTERING INFORMATION]     230 --&gt; 250   </pre>		

SIGNAL ADAPTIVE FILTERING METHOD,  
SIGNAL ADAPTIVE FILTER AND COMPUTER READABLE MEDIUM  
FOR STORING PROGRAM THEREFOR

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Technical Field

The present invention relates to data filtering, and more particularly, to a signal adaptive filtering method for reducing blocking effect and ringing noise, a signal adaptive filter and a computer readable medium for storing a program 10 therefor.

Background Art

Generally, picture encoding standards such as MPEG of the International Standardization Organization (ISO) and H.263 recommended by the International 15 Telecommunication Union (ITU) adopt block-based motion estimation and discrete cosine transform (DCT) blocks. When an image is highly compressed, the block-based coding may cause the well-known blocking effect. A typical blocking effect is grid noise in a homogeneous area in which adjacent pixels have relatively similar pixel values. Another blocking effect is staircase noise which has a staircase shape 20 and is generated along the edges of the image. Also, ringing noise is a typical Gibb's phenomenon occurring by truncation when the coefficients of the DCT are quantized so as to highly compress the image.

Grid noise shows traces of the block-based process at the edges between blocks when the compressed data is displayed on a screen after being restored. 25 Thus, one can identify the edges between blocks. Also, staircase noise has a staircase shape at the edges of the image, so that one can notice a bumpy edge on the image. Also, one can notice overlapping of images with a predetermined interval due to the ringing noise.

In order to reduce the blocking effect and the ringing noise occurring when 30 block-based coding is performed, several methods have been suggested. According to H.261 encoding, a simple  $3 \times 3$  low-pass filter (LPF) is used as a loop filter to reduce the blocking effect [*"Video Codec for Audiovisual Services at P×62 kbit/s"*,

CCITT Recommendation H.261, December 14, 1990]. Also, a simple edge loop filter has been suggested so as to reduce the blocking effect and mosquito noise [G.Bjontegaard, "A Simple Edge Loop Filter to Reduce Blocking and Mosquito Noise", ISO/IEC JTC1/Sc29/WG11 MPEG96/0617, January, 1996, and "A Simple Edge Loop Filter to Reduce Blocking and Mosquito Noise", ITU SC15 LBC Expert Group ITU-LBC-96-032, January, 1996]. The edge loop filter makes linear values of two pixels adjacent to the block boundary and replaces the two pixel values by the linearized values. Such edge loop filter can reduce the blocking effect but not the ringing noise. In order to reduce the ringing noise, a non-linear filter using a binary index has been suggested [Y.Itoh, "Detail Preserving Nonlinear Filter using Binary Index, "ISO/IEC JTC1/SC29/WG11 MPEG95/0357, November, 1995]. However, the non-linear filter cannot reduce the blocking effect.

#### Disclosure of the Invention

15 To solve the above problems, it is an object of the present invention is to provide an signal adaptive filtering method for reducing blocking effect and ringing noise in high compression encoding, a signal adaptive filter, and a computer readable medium.

According to an aspect of the present invention, there is provided a signal 20 adaptive filtering method capable of reducing blocking effect and ringing noise of image data when a frame is composed of blocks of a predetermined size, the method comprising the steps of: (a) generating blocking information for reducing the blocking effect and ringing information for reducing the ringing noise, from coefficients of predetermined pixels of the upper and left boundary regions of the 25 data block when a frame obtained by deconstructing a bitstream image data for inverse quantization is an intraframe; and (b) adaptively filtering the image data passed through inverse quantization and inverse discrete cosine transform according to the generated blocking information and ringing information.

30 Preferably, the step (a) further comprises the step of setting the blocking information and ringing information of the previous frame corresponding to a motion vector as blocking information and ringing information of the current frame if the frame is an interframe, and setting the ringing information to "1" which

represents the image data requiring filtering if a residual signal of the inverse-quantized current block exists, and the blocking information and ringing information are determined according to coefficients of a pixel A located at the upper left corner of the block, a pixel B located to the right of the pixel A and a 5 pixel C located below the pixel A.

Preferably, the blocking information is constituted of horizontal blocking information and vertical blocking information, and the horizontal blocking information is set to "1" which means the image data requiring filtering when only the coefficient of the pixel A is not equal to "0" or any coefficient of the pixels of 10 the left boundary region of the block is not equal to "0", and the vertical blocking information is set to "1" which means the image data requiring filtering when only the coefficient of the pixel A is not equal to "0" or any coefficient of the pixels of the upper boundary region of the block is not equal to "0", and the ringing information is set to "1" which means the image data requiring filtering when any 15 coefficient of the pixels other than the pixels A, B and C of the block is not equal to "0".

Preferably, the blocking information is constituted of horizontal blocking information and vertical blocking information, and the horizontal blocking information is set to "1" which means the image data requiring filtering when all 20 coefficients of the pixels A, B and C of the block are not equal to "0" or any coefficient of the pixels of the left boundary region of the block is not equal to "0", and the vertical blocking information is set to "1" which means the image data requiring filtering when all coefficients of the pixels A, B and C are not equal to "0" or any coefficient of the pixels of the upper boundary region of the block is not 25 equal to "0", and the ringing information is set to "1" which means the image data requiring filtering when any coefficient of the pixels other than the pixels A, B and C of the block is not equal to "0".

Preferably, in order to reduce the blocking effect, in the step (b), the horizontal (or vertical) filtering is performed using a weighted filter having a 30 predetermined weighted value when the horizontal (or vertical) blocking information of the block is equal to "1" and the ringing information is equal to "0", and when the horizontal (or vertical) blocking information of the block is not equal

to "1" or the ringing information is not equal to "0", an absolute value of the difference between adjacent pixels and a Q value used as a dividend for quantizing the block are compared, and then filtering is performed with a predetermined value according to the result of the comparison.

- 5 According to another aspect of the present invention, there is provided a signal adaptive filter capable of reducing blocking effect and ringing noise of image data when a frame is composed of blocks of a predetermined size, comprising: a mode flag checking unit for checking a flag to determine whether or not a frame is an intraframe or an interframe when a bitstream image data is deconstructed for  
10 inverse quantization; an intra filtering information generator for generating blocking information for reducing the blocking effect and ringing information for reducing the ringing noise, from coefficients of predetermined pixels of the upper and left boundary regions of the data block when the frame is determined as an intraframe by the mode flag checking unit; an inter filtering information generator for setting  
15 the blocking information and ringing information of the previous frame corresponding to a motion vector as blocking information and ringing information of the current frame if the frame is an interframe, and setting the ringing information to "1" if a residual signal of the inverse-quantized current block exists; and an adaptive filter for adaptively filtering the image data passed through an  
20 inverse quantizer and an inverse discrete cosine transformer according to the blocking information and the ringing information generated by the intra filtering information generator and the inter filtering information generator.

The invention may be embodied in a general purpose digital computer that is running a program from a computer usable medium, including but not limited to  
25 storage media such as magnetic storage media (e.g., ROM's, floppy disks, hard disks, etc.), optically readable media (e.g., CD-ROMs, DVDs, etc.) and carrier waves (e.g., transmissions over the Internet). Hence, the present invention may be embodied as a computer usable medium.

- According to still another aspect of the present invention, there is provided  
30 a computer readable medium having embodied thereon a computer program for a signal adaptive filtering capable of reducing blocking effect and ringing noise of image data when a frame is composed of blocks of a predetermined size, wherein

the signal adaptive filtering comprises the steps of: (a) generating blocking information for reducing the blocking effect and ringing information for reducing the ringing noise, from coefficients of predetermined pixels of the upper and left boundary regions of the data block when a frame obtained by deconstructing a 5 bitstream image data for inverse quantization is an intraframe; (b) setting the blocking information and ringing information of the previous frame corresponding to a motion vector as blocking information and ringing information of the current frame if the frame is an interframe, and setting the ringing information to "1" which represents the image data requiring filtering if a residual signal of the 10 inverse-quantized current block exists; and (c) adaptively filtering the image data passed through the inverse quantization and inverse discrete cosine transform based on the block according to the generated blocking information and ringing information.

Also, there is provided a computer readable medium having embodied 15 thereon a computer program for a method of filtering ringing noise caused when decoding a block-based compressed image data, wherein the ringing noise filtering method comprises the steps of: (a) performing a gradient operation on the block subjected to inverse quantization and inverse discrete cosine transform using predetermined one-dimensional horizontal and vertical gradient operators; (b) 20 generating a binary edge map representing whether or not each pixel is an edge pixel, using an absolute value of the difference between the gradient-operated value of one pixel and the value of the adjacent pixel, and a Q value used as a dividend for quantizing the block; and (c) performing a filtering by applying a predetermined filter window to the generated binary edge map.

25

#### Brief Description of the Drawings

FIG. 1 is a block diagram of a signal adaptive filter for reducing blocking effect and ringing noise according to the present invention;

FIG. 2 is a flowchart illustrating a signal adaptive filtering method according 30 to a preferred embodiment of the present invention;

FIG. 3 shows an inverse-quantized block having  $8 \times 8$  pixels;

FIG. 4 is a flowchart illustrating the step of generating information used to

filter an intraframe;

FIG. 5 is a flowchart illustrating the step of generating information used to filter an interframe;

FIG. 6 shows the location of pixels adjacent to the block boundary for 5 illustrating the filtering for reducing blocking effect; and

FIG. 7 shows the location of pixels to be processed in the current block.

#### Best mode for carrying out the Invention

In FIG. 1, a signal adaptive filter for reducing blocking effect and ringing 10 noise according to the present invention includes a mode flag checking unit 120, an intra filtering information generator 130, an inter filtering information generator 140 and an adaptive filter unit 150. When bitstream image data is deconstructed for inverse quantization, the mode flag checking unit 120 checks whether or not the frame is an intra frame or an inter frame. The intra filtering information generator 15 130 generates blocking information for reducing blocking effect and ringing information from coefficients of predetermined pixels of the upper and left boundary regions of the data block when the frame is determined as an intra frame by the mode flag checking unit 120. When the mode flag checking unit 120 determines the frame as an inter frame, the inter filtering information generator 140 20 generates blocking information and ringing information of the previous frame corresponding to a motion vector as blocking information and ringing information of the current frame. If a residual signal of the inverse-quantized current block exists, the ringing information is set to "1". The adaptive filtering unit 150 adaptively filters the image data of the block which has passed an inverse quantizer 25 ( $Q^{-1}$ ) 100 and an inverse discrete cosine transformer (DCT $^{-1}$ ) 110 according to the blocking information and ringing information generated by the intra filtering information generator 130 and the inter filtering information generator 140.

Meanwhile, a signal adaptive filtering method according to a preferred embodiment of the present invention will be described. FIG. 2 is a flowchart 30 illustrating the signal adaptive filtering method according to the present invention. Bitstream image data coded by an encoder is decoded by a decoder to be reproduced. To end this, the bitstream data is deconstructed and then inverse-

quantized by the inverse quantizer 100 (step 200). Here, the image data is constituted of a plurality of frames, and each frame is constituted of a plurality of blocks. FIG. 3 shows an inverse-quantized block having  $8 \times 8$  pixels which form the frame.

5 Before filtering the frame data with the inverse discrete cosine transform (IDCT), a flag is checked in order to make a determination as to whether or not the frame is an intraframe or an interframe (step 210). If the frame is an intraframe (step 220), information used to filter the intraframe is generated (step 230). If the frame is an interframe, information used to filter the interframe is generated (step 10 240). Then, the frame data which has passed through the IDCT 110 are adaptively filtered according to the generated filtering information, thereby eliminating blocking effect and ringing noise (step 250).

15 FIG. 4 is a flowchart illustrating in detail the step of generating information used to filter the intraframe. As shown in FIG. 4, if the frame is determined as an intraframe by the mode flag checking unit 120, the coefficient of pixel A of FIG. 3 is checked (step 400). If only the coefficient of the pixel A is not equal to "0", horizontal blocking information (HBI) and vertical blocking information (VBI) are set to "1" (step 410). If any coefficient of pixels (8 pixels including the pixels A and B) belonging to the upper boundary region 300 of the block shown in FIG. 3 20 is not equal to "0" (step 420), the VBI is set to "1" (step 430). Otherwise, the VBI is set to "0" (step 440). Also, if any coefficient of pixels (8 pixels including the pixels A and C) belonging to the left boundary region 310 of the block shown in FIG. 3 is not equal to "0" (step 450), the HBI is set to "1" (step 460). Otherwise, the HBI is set to "0" (step 470).

25 After the HBI and VBI are set, ringing information (RI) used to filter the ringing noise is generated. That is, if any coefficient of pixels other than the pixels A, B and C of the block shown in FIG. 3 is not equal to "0" (step 480), the RI is set to "1" (step 490). Otherwise, the RI is set to "0" (step 495). Here, the HBI and VBI are set to "1" when only the coefficient of the pixel A is not equal to "0" 30 (step 400). However, by setting the HBI and VBI to "1" even if all coefficients of the pixels A, B and C are not equal to "0", favorable effect to some extent can be obtained when a signal adaptive filtering is performed later.

FIG. 5 is a flowchart illustrating the step of generating information used to filter the interframe. If the frame is determined as an interframe by the mode flag checking unit 120, the HBI, VBI and RI of the intraframe are transferred to HBI, VBI and RI of the interframe according to the motion vector (step 500). Also, if 5 a residual signal exists after motion compensation (step 510), the RI is updated (step 520).

When the blocking information and ringing information for filtering are generated as described above, filtering is adaptively performed according to the information. First, a filtering method for reducing blocking effect will be described. The filtering for reducing the blocking effect is classified as one of horizontal filtering and vertical filtering. Here, the horizontal filtering will be explained. FIG. 6 shows the location of pixels adjacent to the block boundary, for illustrating the filtering for reducing the blocking effect. A determination is made as to whether or not the HBI and RI of blocks I and J of FIG. 6 are equal to "0".

15 If the HBI and RI of blocks I and J of FIG. 6 are equal to "0", a weighted filtering is performed on pixels A, B, C, D, E and F of FIG. 6 using a 7-tap (1,1,1,2,1,1,1) low-pass filter (LPF).

If the HBI or the RI of blocks I and J of FIG. 6 is not equal to "0", a filtering is performed on the pixels B, C, D and E using the following algorithm.

```

20      d = D - C;
      If (ABS(d) ≤ Q) {
          D = D - (d/2);      C = C + (d/2);
          d = E - D;
          if (ABS(d) ≤ Q)    E = E - (d/4);
          d = C - B;
          if (ABS(d) ≤ Q)    B = B + (d/4);
      }
      else {
          if (ABS(d/2) ≤ 2Q)
              If (d > 0) {
                  D = D - (Q - ABS(d/2));
              }
      }
  }

```

```

C = C + (Q - ABS(d/2));
}
else {
    D = D + (Q - ABS(d/2));
5    C = C + (Q - ABS(d/2));
}
d = E - D;
if (ABS(d) ≤ Q)    E = E - (d/4);
d = C - B;
10   if (ABS(d) ≤ Q)    B = B - (d/4);
}
}

```

In the above algorithm, ABS represents an absolute value, and Q represents a dividend used when the blocks forming the frame are quantized.

15 In detail, the absolute value (ABS(d)) of the difference (d) between the pixels D and C is equal to or less than Q, the current pixel value of the pixel D is set by subtracting d/2 from the current pixel value, and the current pixel value of the pixel C is set by adding d/2 to the current pixel value. Also, the absolute value (ABS(d)) of the difference (d) between the pixels E and D is equal to or less than 20 Q, the current pixel value of the pixels is set by subtracting d/4 from the current pixel value. Also, if the absolute value (ABS(d)) of the difference (d) between the pixels C and B is equal to or less than Q, the current pixel values of the pixel B is set by subtracting d/4 from the current pixel value. In the same manner as the above, the pixel values of the pixels B, C, D and E are set according to the 25 algorithm other than the above, which is obvious to those skilled in the art, thus the explanation thereof will be omitted. Also, vertical filtering is performed according to the same principle as the horizontal filtering.

Next, a filtering method for reducing ringing noise will be described. First, the generated ringing information is checked. If the ringing information is set to 30 "1", the filtering is performed. Otherwise, the filtering is not performed. To end this, edge pixels of the block which have been subjected to inverse quantization and IDCT are determined. In order to determine the edge pixels, a gradient operation

is performed on the blocks which have been subjected to inverse quantization and IDCT using one-dimensional horizontal and vertical gradient operators.

Then, an absolute value of the difference between one gradient-operated pixel value and the adjacent pixel value, and Q value used as a dividend when 5 quantizing the block, are used to generate a binary edge map representing the edge of each pixel. Here, the block has  $8 \times 8$  pixels, and the size of the binary edge map is represented as a two-dimensional array  $\text{edge}[10][10]$  as shown in FIG. 7.

In order to generate the binary edge map, vertical edge detection and horizontal edge detection are performed. Algorithms for vertical edge and 10 horizontal edge detections are as follows.

```

/* Vertical edge detection */
A1 = ABS(PtrImage[0] - PtrImage[1]);
A2 = (ABS(PtrImage[0] - PtrImage[-1]));
15  if (((A1 > Th)&&(A2 > Th))||(A1 > 5*Th/2)|| (A2) > 5*Th/2))
    Edge[m][n] = 1; /* edge */

else { /* Horizontal edge detection */
    A'1 = ABS(PtrImage[0] - PtrImage[width]);
20    A'2 = (ABS(PtrImage[0] - PtrImage[-width]));
    if (((A'1 > Th)&&(A'2 > Th))||(A'1 > 5*Th/2)|| (A'2) > 5*Th/2))
        Edge[m][n] = 1; /* edge */
}

```

For the vertical edge detection, an absolute value (A1) of the difference 25 between the gradient-operated results of the pixel (PtrImage[0]) on which a determination as to whether or not the pixel is an edge of the block is made, and the right pixel (PtrImage[1]) of the pixel (PtrImage[0]) is calculated. Then, an absolute value (A2) of the difference between the gradient-operated results of the PtrImage[0] and the left pixel (PtrImage[-1]) of the pixel (PtrImage[0]) is 30 calculated. Then, a determination as to whether or not the pixel is an edge is made according to the logic values obtained after the absolute values A1 and A2 are compared with a predetermined threshold value Th, and then the above process is

performed on all pixels of the block. The vertical edge detection is performed according to a logical formula of  $(A1 > Th) \&\& (A2 > Th) \mid\mid (A1 > 5*Th/2) \mid\mid (A2 > 5*Th/2)$ . If the logical formula is true, the pixel is determined as a vertical edge. Otherwise, the pixel is determined to not be a vertical edge.

5 The horizontal edge detection is performed according to the same principle of the horizontal edge detection. First, an absolute value ( $A'1$ ) of the difference between the gradient-operated results of the pixel ( $\text{PtrImage}[0]$ ) on which a determination as to whether or not the pixel is edge of the block is made, and the lower pixel ( $\text{PtrImage}[\text{width}]$ ) of the pixel ( $\text{PtrImage}[0]$ ) is calculated. Then, an  
10 absolute value ( $A'2$ ) of the difference between the gradient-operated results of the pixel ( $\text{PtrImage}[0]$ ) and the upper pixel ( $\text{PtrImage}[-\text{width}]$ ) of the pixel ( $\text{PtrImage}[0]$ ) is calculated. Then, a determination as to whether or not the pixel is an edge is made according to the logic values obtained after the absolute values  
15  $A'1$  and  $A'2$  are compared with a predetermined threshold value  $Th$ , and then the above process is performed on all pixels of the block. The horizontal edge  
20 detection is performed according to a logical formula of  $(A'1 > Th) \&\& (A'2 > Th) \mid\mid (A'1 > 5*Th/2) \mid\mid (A'2 > 5*Th/2)$ . If the logical formula is true, the pixel is determined as a horizontal edge. Otherwise, the pixel is determined to not be a horizontal edge. Here, ' $\&\&$ ' represents logical AND, and ' $\mid\mid$ ' represents logical OR.

Next, filtering is performed by applying a predetermined filter window to the generated binary edge map. The filtering may be performed by a general filtering method by applying a filter window having a predetermined size. However, in this embodiment, filtering is not performed if the central pixel of the  
25 filter window is an edge, while the filtering is performed if the central pixel is not an edge. The filter window may be a general filter window. In this embodiment, a 4-connectivity filter window having five pixels arranged in a cross shape centering one central pixel, as shown in FIG. 7, is used. In FIG. 7, X represents an edge pixel, and the regions other than the regions with "X" represent non-edge  
30 pixels.

Also, if the filter window has no edge pixel, ordinary filtering is performed, while weighted filtering is performed if the edge pixel exists. An example of

weighted filtering is shown in FIG. 7. In FIG. 7, "<<" represents a shift to the left, and ">>" represents a shift to the right.

The invention may be embodied in a general purpose digital computer that is running a program from a computer usable medium, including but not limited to

5 storage media such as magnetic storage media (e.g., ROM's, floppy disks, hard disks, etc.), optically readable media (e.g., CD-ROMs, DVDs, etc.) and carrier waves (e.g., transmissions over the Internet). Hence, the present invention may be embodied as a computer usable medium having a computer readable program code unit embodied therein for signal adaptive filtering, the computer readable

10 program code means in the computer usable medium comprising: computer readable program code means for causing a computer to effect generating blocking information for reducing the blocking effect and ringing information for reducing the ringing noise, from coefficients of predetermined pixels of the upper and left boundary regions of the data block when a frame obtained by deconstructing a

15 bitstream image data for inverse quantization is an intraframe; computer readable program code means for causing a computer to effect setting the blocking information and ringing information of the previous frame corresponding to a motion vector as blocking information and ringing information of the current frame if the frame is an interframe, and setting the ringing information to "1" which

20 represents the image data requiring filtering if a residual signal of the inverse-quantized current block exists; and computer readable program code means for causing a computer to effect adaptively filtering the image data passed through the inverse quantization and inverse discrete cosine transform based on the block according to the generated blocking information and ringing information, for

25 instance. A functional program, code and code segments, used to implement the present invention can be derived by a skilled computer programmer from the description of the invention contained herein.

#### Industrial Applicability

30 As described above, the present invention can remove the blocking noise and the ringing noise from an image restored from an image compressed based on blocks, thereby enhancing the image restored from compression.

What is claimed is:

1. A signal adaptive filtering method capable of reducing blocking effect and ringing noise of image data when a frame is composed of blocks of a predetermined size, the method comprising the steps of:
  - 5 (a) generating blocking information for reducing the blocking effect and ringing information for reducing the ringing noise, from coefficients of predetermined pixels of the upper and left boundary regions of the data block when a frame obtained by deconstructing a bitstream image data for inverse quantization is an intraframe; and
  - 10 (b) adaptively filtering the image data passed through inverse quantization and inverse discrete cosine transform according to the generated blocking information and ringing information.
2. The method of claim 1, wherein the step (a) further comprises the step of setting the blocking information and ringing information of the previous frame corresponding to a motion vector as blocking information and ringing information of the current frame if the frame is an interframe, and setting the ringing information to "1" which represents the image data requiring filtering if a residual signal of the inverse-quantized current block exists.
3. The method of claim 2, wherein the blocking information and ringing information are determined according to coefficients of a pixel A located at the upper left corner of the block, a pixel B located to the right of the pixel A and a pixel C located below the pixel A.
4. The method of claim 3, wherein the blocking information is constituted of horizontal blocking information and vertical blocking information, and the horizontal blocking information is set to "1" which means the image data requiring filtering when only the coefficient of the pixel A is not equal to "0" or any coefficient of the pixels of the left boundary region of the block is not equal to "0", and the vertical blocking information is set to "1" which means the image data requiring filtering when only the coefficient of the pixel A is not equal to "0" or any coefficient of the pixels of the upper boundary region of the block is not equal to "0", and the ringing information is set to "1" which means the image data requiring filtering when any coefficient of the pixels other than the pixels A, B and

C of the block is not equal to "0".

5. The method of claim 3, wherein the blocking information is constituted of horizontal blocking information and vertical blocking information, and the horizontal blocking information is set to "1" which means the image data  
5 requiring filtering when all coefficients of the pixels A, B and C of the block are not equal to "0" or any coefficient of the pixels of the left boundary region of the block is not equal to "0", and the vertical blocking information is set to "1" which means the image data requiring filtering when all coefficients of the pixels A, B and C are not equal to "0" or any coefficient of the pixels of the upper boundary  
10 region of the block is not equal to "0", and the ringing information is set to "1" which means the image data requiring filtering when any coefficient of the pixels other than the pixels A, B and C of the block is not equal to "0".

6. The method of claim 4 or 5, wherein in order to reduce the blocking effect, in the step (b), the horizontal filtering is performed using a weighted filter  
15 having a predetermined weighted value when the horizontal blocking information of the block is equal to "1" and the ringing information is equal to "0", and when the horizontal blocking information of the block is equal to "1" or the ringing information is not equal to "0", an absolute value of the difference between adjacent pixels and a Q value used as a dividend for quantizing the block are  
20 compared, and then filtering is performed with a predetermined value according to the result of the comparison.

7. The method of claim 4 or 5, wherein in order to reduce the blocking effect, in the step (b), the vertical filtering is performed using a weighted filter having a predetermined weighted value when the vertical blocking information of  
25 the block is equal to "1" and the ringing information is equal to "0", and when the vertical blocking information of the block is equal to "1" or the ringing information is not equal to "0", an absolute value of the difference between adjacent pixels and a Q value used as a dividend for quantizing the block are compared, and then filtering is performed with a predetermined value according to the result of the  
30 comparison.

8. The method of claim 6, wherein assuming that the block has a size of  $8 \times 8$  pixels, and pixels of a  $1 \times 6$  window located centering the boundary of the

block are p1, p2, p3, p4, p5 and p6, in order to reduce the blocking effect, the filtering is performed on the pixels p1, p2, p3, p4, p5 and p6 along the left vertical boundary of the block using the weighted filter having a weighted value (1,1,1,2,1,1,1) when the horizontal blocking information of the block is equal to 5 "1" and the ringing information is equal to "0", and when the horizontal blocking information of the block is not equal to "1" or the ringing information is not equal to "0", the filtering is performed on the pixels p2, p3, p4 and p5 according to the following algorithm:

```

10  d = p4 - p3;
  If (ABS(d) ≤ Q) {
    p4 = p4 - (d/2);    p3 = p3 + (d/2);
    d = p5 - p4;
    if (ABS(d) ≤ Q)    p5 = p5 - (d/4);
15  d = p3 - p2;
    if (ABS(d) ≤ Q)    p2 = p2 + (d/4);
  }
  else {
    if (ABS(d/2) ≤ 2Q)
20    If (d > 0) {
      p4 = p4 - (Q - ABS(d/2));
      p3 = p3 + (Q - ABS(d/2));
    }
    else {
      p4 = p4 + (Q - ABS(d/2));
      p3 = p3 + (Q - ABS(d/2));
    }
25    d = p5 - p4;
    if (ABS(d) ≤ Q)    p5 = p5 - (d/4);
30    d = p3 - p2;
    if (ABS(d) ≤ Q)    p2 = p2 - (d/4);
  }

```

},

where Q is a dividend used for quantizing the block, ABS represents an absolute value, and "=" means that the value of the right side of the equation is replaced by the value of the left side.

5        9.      The method of claim 7, wherein assuming that the block has a size of  $8 \times 8$  pixels, and pixels of a  $6 \times 1$  window located centering the boundary of the block are p1, p2, p3, p4, p5 and p6, in order to reduce the blocking effect, the filtering is performed on the pixels p1, p2, p3, p4, p5 and p6 along the upper horizontal boundary of the block using the weighted filter having a weighted value  
10      (1,1,1,2,1,1,1) when the vertical blocking information of the block is equal to "1" and the ringing information is equal to "0", and when the vertical blocking information of the block is not equal to "1" or the ringing information is not equal to "0", the filtering is performed on the pixels p2, p3, p4 and p5 according to the following algorithm:

15

```

d = p4 - p3;
If (ABS(d) ≤ Q) {
    p4 = p4 - (d/2);    p3 = p3 + (d/2);
    d = p5 - p4;
20      if (ABS(d) ≤ Q)    p5 = p5 - (d/4);
    d = p3 - p2;
    if (ABS(d) ≤ Q)    p2 = p2 + (d/4);
}
else {
25      if (ABS(d/2) ≤ 2Q)
        If (d > 0) {
            p4 = p4 - (Q - ABS(d/2));
            p3 = p3 + (Q - ABS(d/2));
        }
30      else {
            p4 = p4 + (Q - ABS(d/2));
            p3 = p3 + (Q - ABS(d/2));
        }
}
```

```

        }

        d = p5 - p4;
        if (ABS(d) ≤ Q)      p5 = p5 - (d/4);
        d = p3 - p2;
5       if (ABS(d) ≤ Q)      p2 = p2 - (d/4);
        }

},

```

where Q is a dividend used for quantizing the block, ABS represents an absolute value, and "=" means that the value of the right side of the equation is replaced 10 by the value of the left side.

10. The method of claim 6 or 7, wherein in order to reduce the ringing noise, the method further comprises the step of checking the ringing information and performing a predetermined filtering if the ringing information is set to "1", and omitting the filtering if the ringing information is not set to "1".

15. 11. The method of claim 10, wherein the predetermined filtering comprises the steps of:

(x) performing a gradient operation on the block passed through inverse quantization and inverse discrete cosine transform using predetermined one-dimensional horizontal and vertical gradient operators so as to determined an edge 20 pixel;

(y) generating a binary edge map representing whether or not each pixel is an edge pixel, using an absolute value of the difference between the gradient-operated value of one pixel and the value of the adjacent pixel, and a Q value used as a dividend for quantizing the block; and

25 (z) performing filtering by applying a predetermined filter window to the generated binary edge map.

12. The method of claim 11, wherein the step (y) comprises a vertical edge detection step (y1) and a horizontal edge detection step (y2), and the step (y1) comprises the sub-steps of:

30 (y11) calculating an absolute value A1 of the difference between the gradient-operated values on a pixel P1 on which a determination has been made as to whether it is an edge pixel or not and the pixel to the right of the pixel P1;

(y12) calculating an absolute value A2 of the difference between the gradient-operated values on the pixel P1 and the pixel to the left of the pixel P1;

(y13) comparing the absolute values A1 and A2 with a predetermined threshold value Th and determining whether or not the pixel P1 is a vertical edge  
5 pixel according to the logical value as the result of the comparison; and

(y14) performing the above sub-steps (y11) through (y13) on all the pixels of the block, and the step (y2) comprises the sub-steps of:

(y21) calculating an absolute value A'1 of the difference between the gradient-operated values on a pixel P1 on which a determination has been made as  
10 to whether it is an edge pixel of the block or not and the pixel below the pixel P1;

(y22) calculating an absolute value A'2 of the difference between the gradient-operated values on the pixel P1 and the upper pixel of the pixel P1;

(y23) comparing the absolute values A'1 and A'2 with a redetermined threshold value Th and determining whether or not the pixel P1 is a horizontal edge  
15 pixel according to the logical value as the result of the comparison; and

(y24) performing the above sub-steps (y21) through (y23) on all the pixels of the block.

13. The method of claim 12, wherein in the sub-step (y13), the pixel P1 is determined as an edge pixel if a logical formula of  $(A1 > Th) \&\& (A2 > Th) \mid\mid (A1 > 5*Th/2) \mid\mid (A2 > 5*Th/2)$  is true, and the pixel P1 is determined as a non-edge pixel if the logical formula is false, and in the sub-step (y23), the pixel P1 is determined as an edge pixel if a logical formula of  $(A'1 > Th) \&\& (A'2 > Th) \mid\mid (A'1 > 5*Th/2) \mid\mid (A'2 > 5*Th/2)$ , is true and the pixel P1 is determined as a non-edge pixel if the logical formula is false, where  $\&\&$  of the above logical formulae  
20 represents an AND operation, and  $\mid\mid$  represents an OR operation.

14. The method of claim 11, wherein in the step (z), after applying the filter window having a predetermined size to the generated binary edge, filtering is not performed if the central pixel of the filter window is an edge pixel, and the filtering is performed if the central pixel is a non-edge pixel, and an average  
30 filtering is performed if the filter window has no edge pixel and weighted filtering is performed if the filter window has an edge pixel.

15. A method of filtering ringing noise caused when decoding a block-

based compressed image data, the method comprising the steps of:

- (a) performing a gradient operation on the block subjected to inverse quantization and inverse discrete cosine transform using predetermined one-dimensional horizontal and vertical gradient operators;
- 5 (b) generating a binary edge map representing whether or not each pixel is an edge pixel, using an absolute value of the difference between the gradient-operated value of one pixel and the value of the adjacent pixel, and a Q value used as a dividend for quantizing the block; and
- 10 (c) performing a filtering by applying a predetermined filter window to the generated binary edge map.

16. The method of claim 15, wherein the step (y) comprises a vertical edge detection step (y1) and a horizontal edge detection step (y2), and the step (y1) comprises the sub-steps of:

15 (y11) calculating an absolute value A1 of the difference between the gradient-operated values on a pixel P1 on which a determination has been made as to whether it is an edge pixel or not and the pixel to the right of the pixel P1;

(y12) calculating an absolute value A2 of the difference between the gradient-operated values on the pixel P1 and the pixel to the left of the pixel P1;

20 (y13) comparing the absolute values A1 and A2 with a predetermined threshold value Th and determining whether or not the pixel P1 is a vertical edge pixel according to the logical value as the result of the comparison; and

(y14) performing the above sub-steps (y11) through (y13) on all the pixels of the block, and the step (y2) comprises the sub-steps of:

25 (y21) calculating an absolute value A'1 of the difference between the gradient-operated values on a pixel P1 on which a determination has been made as to whether it is an edge pixel of the block or not and the pixel below the pixel P1;

(y22) calculating an absolute value A'2 of the difference between the gradient-operated values on the pixel P1 and the upper pixel of the pixel P1;

30 (y23) comparing the absolute values A'1 and A'2 with a redetermined threshold value Th and determining whether or not the pixel P1 is a horizontal edge pixel according to the logical value as the result of the comparison; and

(y24) performing the above sub-steps (y21) through (y23) on all the pixels

of the block.

17. The method of claim 16, wherein in the sub-step (y13), the pixel P1 is determined as an edge pixel if a logical formula of  $(A1 > Th) \&\& (A2 > Th) || (A1 > 5*Th/2) || (A2) > 5*Th/2$  is true, and the pixel P1 is determined as a non-edge pixel if the logical formula is false, and in the sub-step (y23), the pixel P1 is determined as an edge pixel if a logical formula of  $(A'1 > Th) \&\& (A'2 > Th) || (A'1 > 5*Th/2) || (A'2) > 5*Th/2$  is true, and the pixel P1 is determined as a non-edge pixel if the logical formula is false, where  $\&\&$  of the above logical formulae represents an AND operation, and  $||$  represents an OR operation.

10 18. The method of claim 15, wherein in the step (z), after applying the filter window having a predetermined size to the generated binary edge, filtering is not performed if the central pixel of the filter window is an edge pixel, and the filtering is performed if the central pixel is a non-edge pixel, and an average filtering is performed if the filter window has no edge pixel and weighted filtering  
15 is performed if the filter window has an edge pixel.

19. A signal adaptive filter capable of reducing blocking effect and ringing noise of image data when a frame is composed of blocks of a predetermined size, comprising:

20 a mode flag checking unit for checking a flag to determine whether or not a frame is an intraframe or an interframe when a bitstream image data is deconstructed for inverse quantization;

25 an intra filtering information generator for generating blocking information for reducing the blocking effect and ringing information for reducing the ringing noise, from coefficients of predetermined pixels of the upper and left boundary regions of the data block when the frame is determined as an intraframe by the mode flag checking unit;

30 an inter filtering information generator for setting the blocking information and ringing information of the previous frame corresponding to a motion vector as blocking information and ringing information of the current frame if the frame is an interframe, and setting the ringing information to "1" if a residual signal of the inverse-quantized current block exists; and

an adaptive filter for adaptively filtering the image data passed through an

inverse quantizer and an inverse discrete cosine transformer according to the blocking information and the ringing information generated by the intra filtering information generator and the inter filtering information generator.

20. The signal adaptive filter of claim 19, wherein the adaptive filter 5 performs weighted filtering or average filtering, or does not perform the filtering according to the blocking information and ringing information.

21. A computer readable medium having embodied thereon a computer program for a signal adaptive filtering capable of reducing blocking effect and ringing noise of image data when a frame is composed of blocks of a predetermined 10 size,

wherein the signal adaptive filtering comprises the steps of:

(a) generating blocking information for reducing the blocking effect and ringing information for reducing the ringing noise, from coefficients of predetermined pixels of the upper and left boundary regions of the data block when 15 a frame obtained by deconstructing a bitstream image data for inverse quantization is an intraframe;

(b) setting the blocking information and ringing information of the previous frame corresponding to a motion vector as blocking information and ringing information of the current frame if the frame is an interframe, and setting the 20 ringing information to "1" which represents the image data requiring filtering if a residual signal of the inverse-quantized current block exists; and

(c) adaptively filtering the image data passed through the inverse quantization and inverse discrete cosine transform based on the block according to the generated blocking information and ringing information.

25. 22. The computer readable medium of claim 21, wherein assuming that a pixel A is located at the upper left corner of the block, a pixel B is located to the right of the pixel A and a pixel C is located below the pixel A, the blocking information is constituted of horizontal blocking information and vertical blocking information, and the horizontal blocking information is set to "1" which means the 30 image data requiring filtering when only the coefficient of the pixel A is not equal to "0" or any coefficient of the pixels of the left boundary region of the block is not equal to "0", and the vertical blocking information is set to "1" which means

the image data requiring filtering when only the coefficient of the pixel A is not equal to "0" or any coefficient of the pixels of the upper boundary region of the block is not equal to "0", and the ringing information is set to "1" which means the image data requiring filtering when any coefficient of the pixels other than the 5 pixels A, B and C of the block is not equal to "0".

23. The computer readable medium of claim 21, wherein assuming that a pixel A is located at the upper left corner of the block, a pixel B is located to the right of the pixel A and a pixel C is located below the pixel A, the blocking information is constituted of horizontal blocking information and vertical blocking 10 information, and the horizontal blocking information is set to "1" which means the image data requiring filtering when all coefficients of the pixels A, B and C of the block are not equal to "0" or any coefficient of the pixels of the left boundary region of the block is not equal to "0", and the vertical blocking information is set to "1" which means the image data requiring filtering when all coefficients of the 15 pixels A, B and C are not equal to "0" or any coefficient of the pixels of the upper boundary region of the block is not equal to "0", and the ringing information is set to "1" which means the image data requiring filtering when any coefficient of the pixels other than the pixels A, B and C of the block is not equal to "0".

24. The computer readable medium of claim 22 or 23, wherein in order 20 to reduce the blocking effect, in the step (c), the filtering is performed using a weighted filter having a predetermined weighted value when the blocking information of the block is equal to "1" and the ringing information is equal to "0", and when the blocking information of the block is equal to "1" or the ringing information is not equal to "0", an absolute value of the difference between 25 adjacent pixels and a Q value used as a dividend for quantizing the block are compared, and then filtering is performed with a predetermined value according to the result of the comparison.

25. The computer readable medium of claim 24, wherein assuming that the block has a size of  $8 \times 8$  pixels, and pixels of a  $1 \times 6$  window located centering 30 the boundary of the block are p1, p2, p3, p4, p5 and p6, in order to reduce the blocking effect, the filtering is performed on the pixels p1, p2, p3, p4, p5 and p6 along the left vertical boundary of the block using the weighted filter having a

weighted value (1,1,1,2,1,1,1) when the horizontal blocking information of the block is equal to "1" and the ringing information is equal to "0", and when the horizontal blocking information of the block is not equal to "1" or the ringing information is not equal to "0", the filtering is performed on the pixels p2, p3, p4 and p5 according to the following algorithm:

```

d = p4 - p3;
If (ABS(d) ≤ Q) {
    p4 = p4 - (d/2);    p3 = p3 + (d/2);
10   d = p5 - p4;
    if (ABS(d) ≤ Q)    p5 = p5 - (d/4);
    d = p3 - p2;
    if (ABS(d) ≤ Q)    p2 = p2 + (d/4);
}
15  else {
    if (ABS(d/2) ≤ 2Q)
        If (d > 0) {
            p4 = p4 - (Q - ABS(d/2));
            p3 = p3 + (Q - ABS(d/2));
20        }
        else {
            p4 = p4 + (Q - ABS(d/2));
            p3 = p3 + (Q - ABS(d/2));
        }
25        d = p5 - p4;
        if (ABS(d) ≤ Q)    p5 = p5 - (d/4);
        d = p3 - p2;
        if (ABS(d) ≤ Q)    p2 = p2 - (d/4);
    }
30    },

```

where Q is a dividend used for quantizing the block, ABS represents an absolute value, and "=" means that the value of the right side of the equation is replaced

by the value of the left side.

26. The computer readable medium of claim 24, wherein assuming that the block has a size of  $8 \times 8$  pixels, and pixels of a  $6 \times 1$  window located centering the boundary of the block are  $p_1, p_2, p_3, p_4, p_5$  and  $p_6$ , in order to reduce the 5 blocking effect, the filtering is performed on the pixels  $p_1, p_2, p_3, p_4, p_5$  and  $p_6$  along the upper horizontal boundary of the block using the weighted filter having a weighted value (1,1,1,2,1,1,1) when the vertical blocking information of the block is equal to "1" and the ringing information is equal to "0", and when the vertical blocking information of the block is not equal to "1" or the ringing 10 information is not equal to "0", the filtering is performed on the pixels  $p_2, p_3, p_4$  and  $p_5$  according to the following algorithm:

```

d = p4 - p3;
If (ABS(d) ≤ Q) {
15      p4 = p4 - (d/2);      p3 = p3 + (d/2);
      d = p5 - p4;
      if (ABS(d) ≤ Q)      p5 = p5 - (d/4);
      d = p3 - p2;
      if (ABS(d) ≤ Q)      p2 = p2 + (d/4);
20    }
else {
      if (ABS(d/2) ≤ 2Q)
          If (d>0) {
              p4 = p4 - (Q - ABS(d/2));
25          p3 = p3 + (Q - ABS(d/2));
          }
      else {
              p4 = p4 + (Q - ABS(d/2));
              p3 = p3 + (Q - ABS(d/2));
30      }
      d = p5 - p4;
      if (ABS(d) ≤ Q)      p5 = p5 - (d/4);
}

```

```

d = p3 - p2;
if (ABS(d) ≤ Q)    p2 = p2 - (d/4);
}
},

```

5 where Q is a dividend used for quantizing the block, ABS represents an absolute value, and "=" means that the value of the right side of the equation is replaced by the value of the left side.

27. A computer readable medium having embodied thereon a computer program for a method of filtering ringing noise caused when decoding a block-based compressed image data,

wherein the ringing noise filtering method comprises the steps of:

(a) performing a gradient operation on the block subjected to inverse quantization and inverse discrete cosine transform using predetermined one-dimensional horizontal and vertical gradient operators;

15 (b) generating a binary edge map representing whether or not each pixel is an edge pixel, using an absolute value of the difference between the gradient-operated value of one pixel and the value of the adjacent pixel, and a Q value used as a dividend for quantizing the block; and

20 (c) performing a filtering by applying a predetermined filter window to the generated binary edge map.

28. The computer readable medium of claim 27, wherein the step (b) comprises a vertical edge detection step (b1) and a horizontal edge detection step (b2), and the step (b1) comprises the sub-steps of:

25 (b11) calculating an absolute value A1 of the difference between the gradient-operated values on a pixel P1 on which a determination has been made as to whether it is an edge pixel or not and the pixel to the right of the pixel P1;

(b12) calculating an absolute value A2 of the difference between the gradient-operated values on the pixel P1 and the pixel to the left of the pixel P1;

30 (b13) comparing the absolute values A1 and A2 with a predetermined threshold value Th and determining the pixel P1 as an edge pixel if a logical formula of  $(A1 > Th) \&& (A2 > Th) | | (A1 > 5*Th/2) | | (A2) > 5*Th/2$  is true, and as non-edge pixel if the logical formula is false, where  $\&&$  of the above logical

formulae represents an AND operation, and  $\mid\mid$  represents an OR operation; and  
(b14) performing the above sub-steps (b11) through (b13) on all the pixels  
of the block, and

the step (b2) comprises the sub-steps of:

- 5 (b21) calculating an absolute value  $A'1$  of the difference between the  
gradient-operated values on a pixel  $P1$  on which a determination has been made as  
to whether it is an edge pixel of the block or not and the pixel below the pixel  $P1$ ;
- (b22) calculating an absolute value  $A'2$  of the difference between the  
gradient-operated values on the pixel  $P1$  and the upper pixel of the pixel  $P1$ ;
- 10 (b23) comparing the absolute values  $A'1$  and  $A'2$  with a redetermined  
threshold value  $Th$  and determining the pixel  $P1$  as an edge pixel if a logical  
formula of  $(A'1 > Th) \&\& (A'2 > Th) \mid\mid (A'1 > 5*Th/2) \mid\mid (A'2 > 5*Th/2)$  is true, and  
as a non-edge pixel if the logical formula is false; and
- 15 (b24) performing the above sub-steps (b21) through (b23) on all the pixels  
of the block.

29. The computer readable medium of claim 27, wherein in the step (c),  
after applying the filter window having a predetermined size to the generated binary  
edge, filtering is not performed if the central pixel of the filter window is an edge  
pixel, and the filtering is performed if the central pixel is a non-edge pixel, and an  
20 average filtering is performed if the filter window has no edge pixel and weighted  
filtering is performed if the filter window has an edge pixel.

FIG. 1

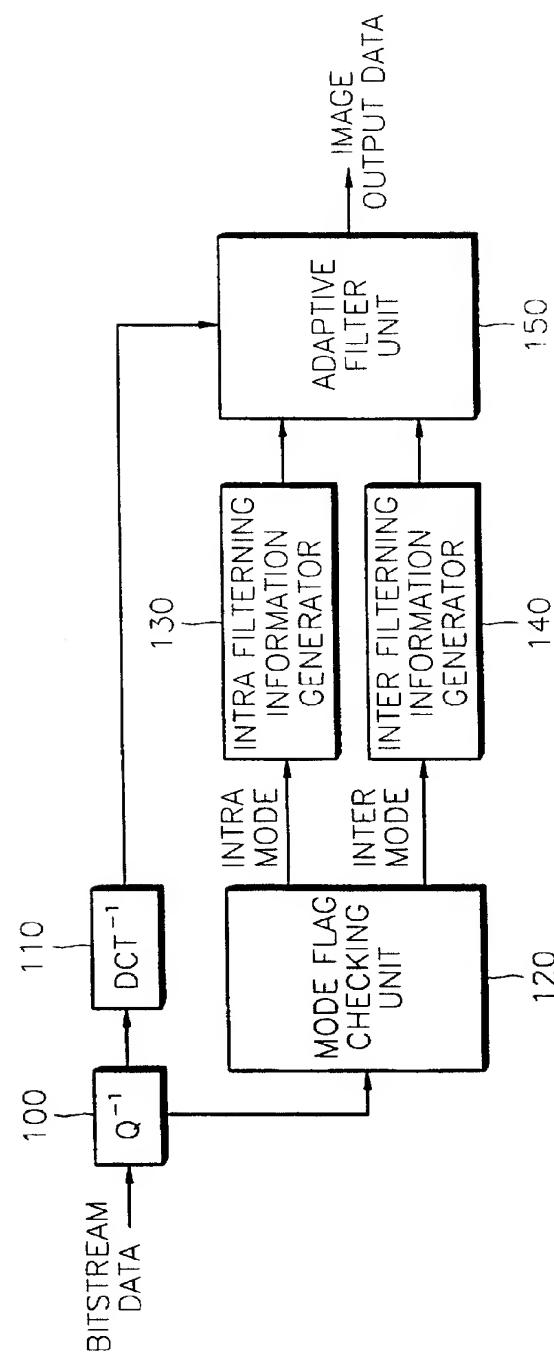


FIG. 2

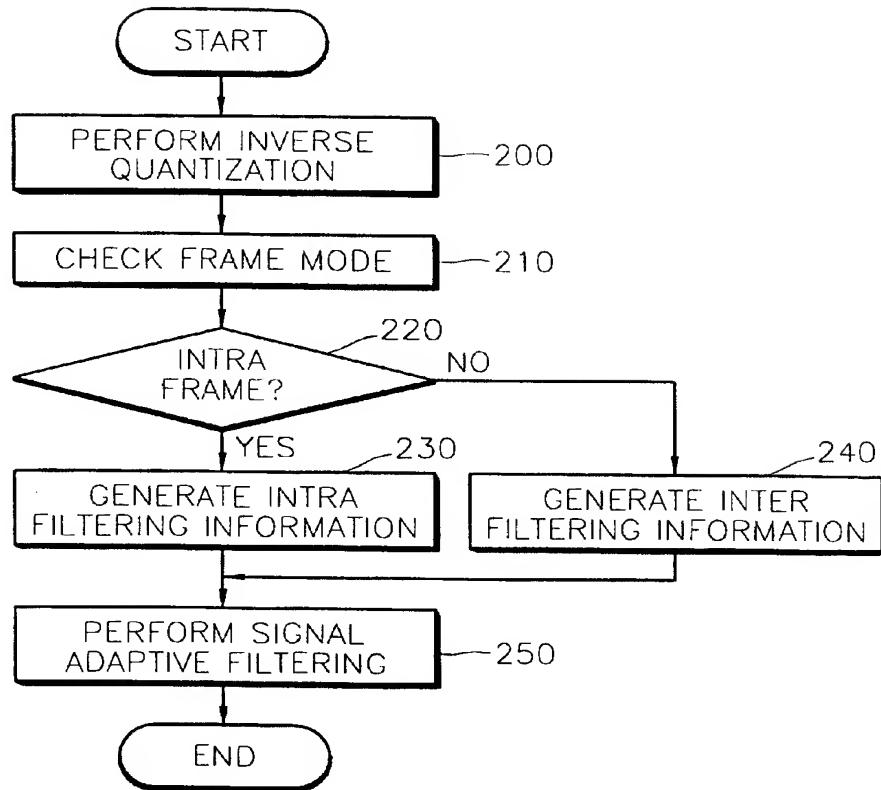


FIG. 3

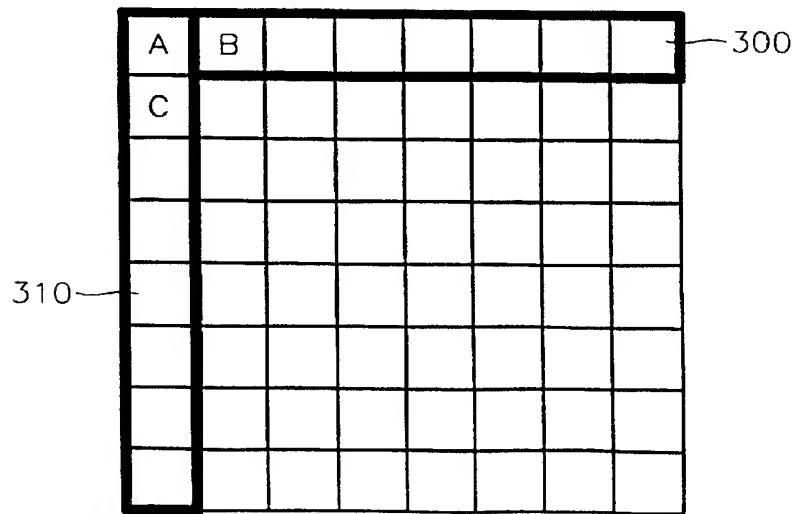


FIG. 4

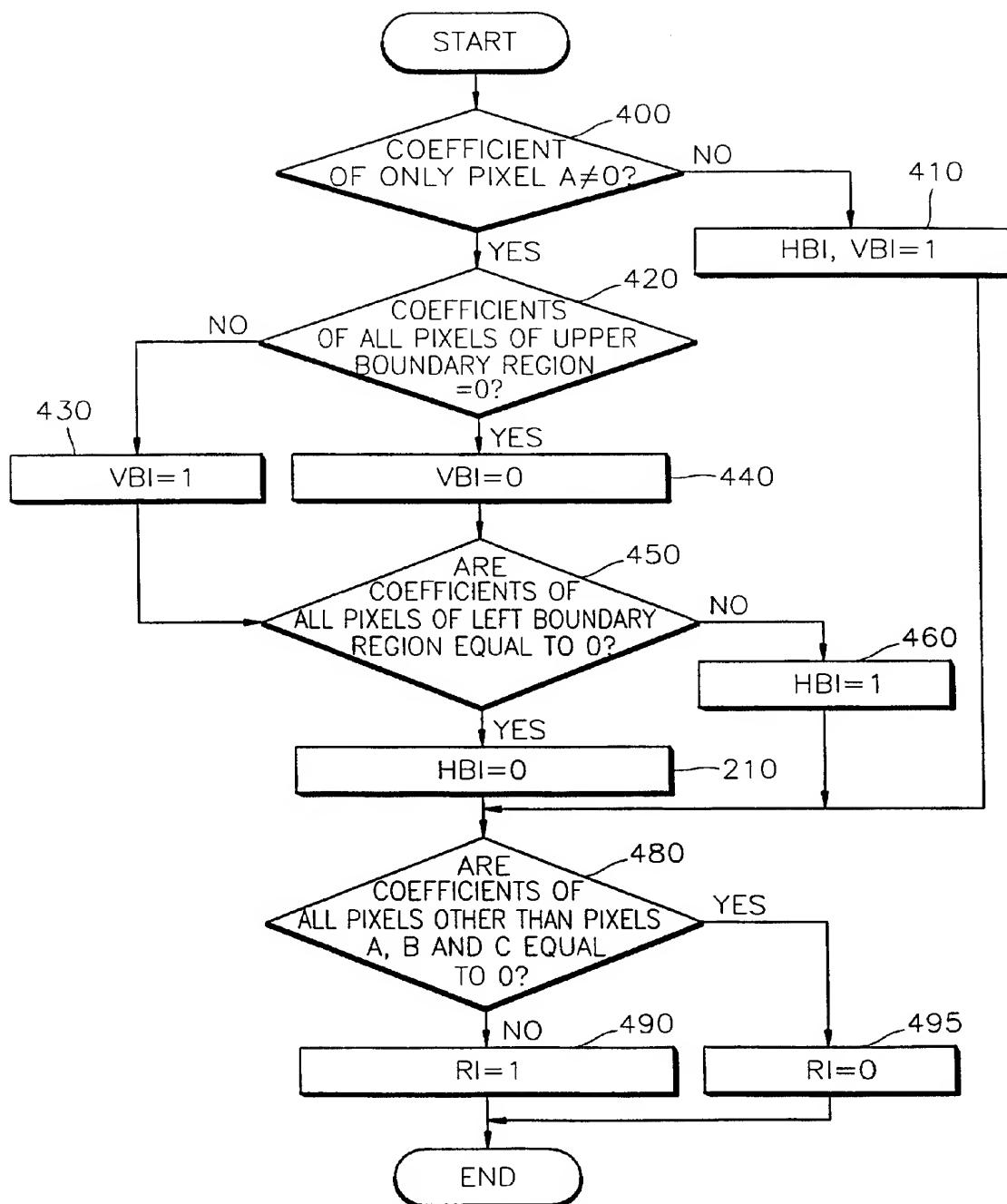


FIG. 5

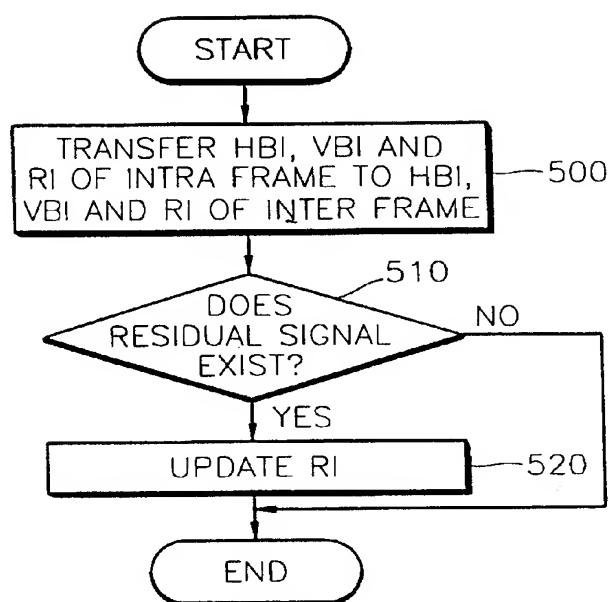


FIG. 6

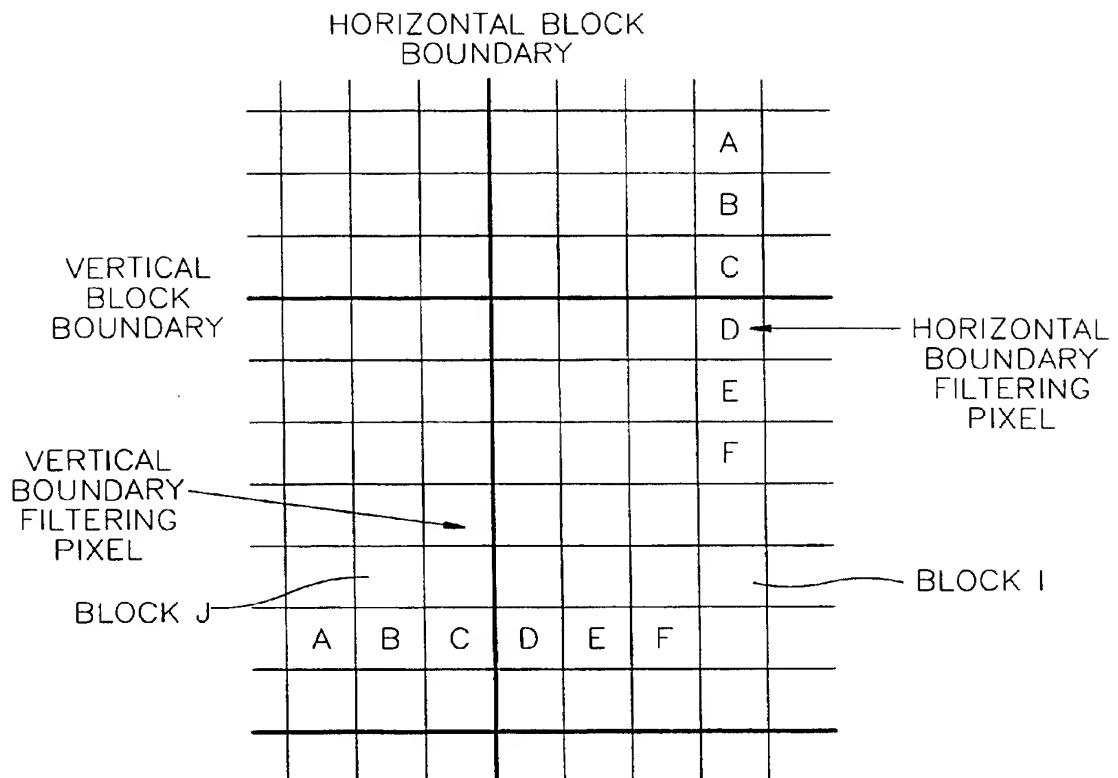


FIG. 7

